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Abstract

A humidifier (1) having an ambient temperature sensor (23) for sensing the temperature of the ambient air in the environment in which the humidifier (1) is located. A difference temperature selector (11) is provided to allow a user to select a difference temperature which is the difference in temperature between the sensed ambient temperature and a comfortable and efficient temperature for supply of the humidified gases provided by the humidifier to a patient or user. The humidifier controls the temperature of the humidifier gases it provides to the patient to the selected difference temperature above the sensed ambient temperature, so that any change in the sensed ambient temperature results in a corresponding change in the temperature of humidified gases supplied to the patient or user.

CLAIMS

1. Apparatus for controlling the temperature of humidified gases supplied by a humidifier (1) comprising heating means (20) to heat water in a humidifying chamber (3) to humidify gases supplied to said chamber (3) and heater control means to control said heating means, characterised in that ambient temperature sensing means (23) are provided to sense the ambient temperature of the surrounding atmosphere and difference temperature selection means (11) for selecting a difference temperature said ambient temperature sensing means (23) providing an indication of the ambient temperature to said control means and said control means controlling the temperature of said humidified gases supplied by said humidifier (1) to a controlled temperature said difference temperature being the difference in temperature between said controlled temperature and the ambient temperature sensed by said ambient temperature sensing means.

2. Apparatus as claimed in claim 1 wherein said heater control means includes algebraic adding means for algebraically adding said selected temperature to said ambient temperature to provide said controlled temperature.

3. Apparatus as claimed in claim 1 or claim 2 wherein said heater control means controls said heating means dependent on the temperature sensed by said ambient temperature sensing means and the temperature selected by said difference temperature selection means to supply heat to said humiditying chamber (3) to provide said humidified gases at said controlled temperature.

4. Apparatus as claimed in any one of the preceding claims wherein a controlled temperature sensing means (9) is provided for sensing the temperature of the humidified gases supplied by said humidifier, said controlled temperature sensing means (9) providing all indication of the temperature of said humidified gases to said control means.

5. Apparatus as claimed in any one of the preceding claims including a conduit (6) provided in gaseous connection with an outlet (5) of said humiditying chamber (3) for supplying humidified gases to a user at a remote end (7) of said conduit (6).

6. Apparatus as claimed in claim 5 wherein said conduit (6) has a conduit heating element (10) therein, said conduit heating element (10) being controlled by said control means to control the temperature of humidified gases within said conduit (6) to said controlled temperature of said remote end (7).

DESCRIPTION

This invention relates to humidifiers of the type for use in providing humidified gases to a user eg. a patient in need of such humidified gases and has been devised particularly though not solely for providing methods of and/or apparatus for controlling the temperature of humidified gases supplied to a user in a home care environment.

It is an object of the present invention to provide methods of and/or apparatus of the type described for controlling the temperature of humidified gases which will at least provide the public with a useful choice.

Accordingly, in one aspect the invention may broadly be said to consist in an apparatus for heating and controlling the temperature of humidified gases supplied by a humidifying chamber mounted in use on said apparatus, said apparatus comprising heating means to heat water in the humidifying chamber to humidify gases supplied to said chamber, heater control means to control said heating means, ambient temperature sensing means to sense the ambient temperature of the surrounding atmosphere and difference temperature selection means for selecting a difference temperature, said ambient temperature sensing means providing an indication of the ambient temperature to said control means and said control means controlling the temperature of said humidified gases supplied by a said humidifying chamber mounted on said apparatus in use to a controlled temperature said difference temperature being the difference in temperature between said controlled temperature and the ambient temperature sensed by said ambient temperature sensing means.

To those skilled in the art to which the invention relates, many changes in construction and widely differing embodiments and applications of the invention will suggest themselves without departing from the scope of the invention as defined in the appended claims. The disclosures and the descriptions herein are purely illustrative and are not intended to be in any sense limiting.

One preferred form of the present invention will now be described with reference to the accompanying drawings in which;
Figure 1 is a perspective view of humidifying apparatus in accordance with the present invention;
Figure 2 is a perspective view of humidifying apparatus in accordance with the present invention;
Figure 3 is a perspective view of a humidifying chamber (not to scale) for use with the apparatus of Figure 2; and
Figure 4 is a simplified circuit diagram of control circuitry for the humidifying apparatus of the preceding figures.
Figure 5 is a simplified block diagram of control circuitry for the humidifying apparatus of the present invention.

Referring to Figure 1 a humidifying apparatus generally referenced 1 is shown. The apparatus comprises a body 2 containing heating means comprising a heating plate 20 having an electric heating element therein or in thermal contact therewith and control means for example electronic circuitry which may include a microprocessor for controlling the supply of energy to the heating element. The body 2 is removably engageable with a humidifying chamber 3 which contains water for humidifying gases. Referring to Figures 2 and 3 which show the humidifier apparatus and the humidifying chamber in more detail, the humidifying chamber 3 has edges 27 which engage with collar 24 on the humidifier apparatus. The gases to be humidified may be a mixture of air, oxygen and anaesthetic for example which are supplied to the chamber through a gases inlet 4.A gases outlet 5 is also provided and the gases outlet 5 is connected to the conduit 6 (Figure 1) which conveys humidified gases to a remote destination such as an intubated patient at the end 7 of the conduit. Alternatively, the end 7 of the conduit may have a gas mask attached thereto which mask is used to cover a nose and/or mouth of a user so as to supply humidified gases to the user for breathing. The humidifier heater plate 20 has a temperature transducer 8 which is in electrical connection with the electronic control circuitry in body 2 of the apparatus so that the control means monitors the temperature of the heating plate and the approximate temperature of the humidified gases at the gases outlet 5.Similarly a further temperature transducer 9 may also be provided at the end 7 of the conduit and this temperature transducer is also in connection with the control circuitry for monitoring the temperature of the humidified gases at the end of the conduit where the humidified gases are supplied to a user. A heating element 10 may also be provided within the conduit 6 to help prevent condensation of the humidified gases within the conduit due to the temperature of the walls of the conduit being close to the ambient temperature, (being the temperature of the surrounding atmosphere) which is usually lower than the temperature of the humidified gases within the conduit.

In a hospital environment, where the ambient temperature of the atmosphere within the hospital environment is controlled by

air conditioning for example, the required temperature for the humidified gases supplied by the apparatus may be controlled within set temperature parameters that are sufficiently close to the ambient temperature to prevent condensation within the conduit 6 but at a sufficiently high temperature to be comfortable and effective when supplied to the patient at end 7 of the conduit.

In the home care environment in which a user requires to use humidifying apparatus at home, the range of ambient and gas temperatures may well exceed that of the hospital environment. In the home care environment, the user will usually wear a face mask which is connected to end 7 of the conduit and such a humidifier may be used in the home environment for use such as the treatment of breathing and sleep apnoea disorders and/or ventilators. Generally in the type of humidifier described above with respect to the hospital environment, gases are regulated to a fixed, preset temperature at transducer 8 or 9; or the water bath within the humidifying chamber 3 is regulated to a fixed, preset temperature; or an open loop controller may regulate power to the water bath. In addition, non active humidifiers are commonly employed utilising the known pass over humidification technique.

When used in the home care environment, all of these commonly employed control techniques may suffer the same disadvantages. In the home care environment the range of ambient and gas temperatures may well exceed that of the hospital environment, with temperatures as low as 10 DEG C achieved overnight, and ambient temperatures over 20 DEG C also possible during time of usage.

Any of these active systems will have, to some degree or other, condensation (or rain out) in the tubing connecting the humidifier to the patient. The degree of condensation is strongly dependent on the ambient temperature, being much greater for greater differences between the ambient temperature and the gas temperature.

The formation of large quantities of water in the breathing tubing causes considerable inconvenience to the patient, may accelerate cooling of the gas, may eventually occlude the tubing, or may be expelled into the patient. Also, the patient may experience discomfort when breathing gases is delivered at temperatures widely divergent from that of the ambient temperature. Excessive condensation also results in inefficient usage of the water in the humidifying chamber 3.

The present invention overcomes or at least assists in overcoming the problem of condensation in the tubing connecting the humidifier to the patient by controlling the temperature of the heating element in heating plate 20 (Figure 2) and thus the temperature of the water in the humidifying chamber 3 to a fixed difference temperature above the ambient temperature of the surrounding atmosphere. This is done by providing a selector 11 on the panel of the humidifier, the selector 11 being capable of being adjusted by a user to a selected difference temperature. The difference temperature selected by the user using the selector 11 is the difference temperature between a desired temperature for supply of humidified gases and the ambient temperature.The selector may thus be used to control the temperature of the humidified gases sensed by transducers 8 or 9 to a desired controlled temperature. The control circuitry (figures 4 and 5) controls the temperature of the heating elements to regulate the temperature of the humidified gases leaving the conduit at transducer 9 by controlling the heating element and heater plate 20 and the conduit heating element 10, so that the temperature of the humidified gases supplied at end 7 of the conduit is governed by a fixed differential temperature to the ambient temperature.

In an alternative embodiment if the conduit heating element 10 and the temperature sensor 9 are not provided, the user must set the differential temperature to ensure that there is minimal condensation occurring in the conduit 6 in use without the temperature or humidity of the humidified gases supplied being too high or low for the gases to be comfortably breathed by a user. The selector 11 may be capable of being adjusted to control heater plate temperature by for example 5-55 DEG C above the sensed ambient temperature. A temperature transducer for measuring the ambient temperature is provided in the humidifier apparatus 2 and supplies signals indicative of the ambient temperature to the control circuitry.It has been observed from our research that the positioning of the ambient temperature transducer should be carefully considered, since the ambient temperature transducer is to indicate ambient temperature. The transducer should be located in a position such that heat generated by the humidifying apparatus does not affect the transducer's measurement.

The ambient temperature sensor may alternatively be constructed in the form of a separate plug-in assembly so that when the plug is connected, the humidifier and the control means act as described above. The plug may be provided at socket 23 (Figure 2) for example. When the plug is disconnected, the humidifier acts in a conventional manner controlling the heater plate to a temperature determined by the temperature selector 11 without reference to the ambient temperature. From the foregoing it will be seen that a humidifier is provided which controls the temperature of the humidified gases produced by the humidifier to a set differential temperature above the sensed ambient temperature of the surrounding atmosphere.

Thus, when the ambient temperature is expected to vary for example in a home care environment, the condensation which will occur at low ambient temperatures in the conduit connecting the humidifier to the patient is minimised and the patient will experience less discomfort since the humidified gases are delivered at temperatures which carry the maximum water vapour without condensation. This also has the advantage of using the water in the humidifying chamber more efficiently so

that the chamber is not required to be refilled as frequently.

Therefore the chamber may not require refilling for a sufficiently long period of time, for example 8 hours.

Referring to Figure 4 the basic control circuit for the present invention is supplied by an alternating current power supply for example a conventional 115 to 230v 50 or 60 Hz AC mains power supply. The control circuitry is connected to the phase and neutral contacts of the power supply and has a ganged on/off switch 30. The on/off switch 30 connects the power supply to a heating element 32 provided in the heater plate 30. The heating element is for example an 85 watt heating element, but elements of other desired heating capacities may be provided. The heating element is connected with the supply by a TRIAC 34 having a gate electrode 36. As a safety precaution, a temperature dependent circuit breaker 38 is provided which is normally closed but which will open when the heater plate 30 exceeds a predetermined temperature, for example 93 DEG C.When such a temperature is reached, the contacts of the circuit breaker 38 will open and prevent any further power being supplied to the heating element to prevent overheating of the apparatus which may result in either damage to the apparatus or injury to the patient. The mains power supply provides power to a further power supply 40 which is a low voltage DC power supply (for example 10 to 15 volts) for supplying power to the electronic circuitry. An amplifier such as an operational amplifier 44 is provided as part of the electronic circuitry and the power supply for the operational amplifier 44 is provided by supply 40. The power supply 40 also supplies power to the resistor networks in which the variable resistance temperature sensors 45 are provided. The supply 40 supplies power to the ambient temperature transducer at point 46, the variable resistance control temperature selector at point 48, and the heater plate temperature transducer at point 50 in the circuit. The ambient temperature transducer and the control temperature selector output are provided to the non-inverting input of the operational amplifier 44. The inverting input of operational amplifier 44 is connected to the output of the heater plate temperature transducer.Thus the signals provided by the control selector and the ambient temperature transducer are added on the noninverting side of the operational amplifier and when the added signal on the non-inverting side of the operational amplifier is greater than the signal supplied to the non-inverting input from the heater plate transducer then the operational amplifier will supply a signal to the gate 36 of the TRIAC 34 to switch the heating element 32 on. When the output of the operational amplifier 44 supplies the "on" signal to the gate 36, an LED 50 is switched on to indicate that the heating element 32 is in the "on" state.

The present invention provides a humidifier and controls for a humidifier which allow humidified gases to be supplied to a patient at a fixed temperature above the ambient temperature of the surrounding atmosphere.

Figure 5 demonstrates a simplified block diagram of an embodiment of the control circuitry incorporating the previously described heater plate controller. An input multiplexer 64 is supplied with a series of inputs including ambient temperature 46, difference temperature 48 and heater plate temperature 50 which control the heating of the heater plate as previously described. A number of other variables may be sensed including the temperature of the humidified gases at end 10 of the conduit. Other possible inputs are provided being referenced 63. The various inputs are multiplexed then electrically filtered by filter 65 before being provided to a microprocessor controller 61.The microprocessor 61 executes steps in a software program which enable it to display information (for example ambient temperature or difference temperature) on a display 67 which is controlled by a display multiplexer and driver 60. The microprocessor 61 also operates an audio alarm 62 upon sensing undesirable circumstances via the inputs or faults. The conduit heater 10 may also be switched on or off upon instructions by the microprocessor 61. The switch 66 may be a TRIAC controlled by the microprocessor m a similar way as is switch 34 in the heater state control circuit. It can be seen that the heater plate controls as previously herein described could also be incorporated in the software program of the microprocessor.

The features disclosed in the foregoing description, in the following claims and/or in the accompanying drawings may, both separately and in any combination thereof, be material for realising the invention in diverse forms thereof.